CHAPTER 5

INTRODUCTION TO MISCELLANEOUS COMMUNICATIONS SYSTEMS AND EQUIPMENT

LEARNING OBJECTIVES

Upon completion of this chapter you will be able to:

1. Describe the basic operation of communications systems that operate at medium frequencies and below.
2. Describe the basic microwave line-of-sight communications system.
3. Describe the basic tropospheric scatter communications system.
4. Describe the objective/purpose of the naval tactical data system (NTDS).
5. Describe the naval tactical data system (NTDS) data transmission subsystems in terms of links.
6. Explain the various applications of portable communications equipment.
7. Define the term laser.
8. Describe the basic theory of operation of lasers
9. Describe the possible applications of lasers in communications.

INTRODUCTION

In the previous four chapters we've looked at communications equipment and systems that were used in several frequency ranges. Some have had many applications. In this chapter you will look at systems used in some portions of the rf spectrum that have not been covered in detail. We will also discuss the naval tactical data system (NTDS), which operates in the high-frequency and ultrahigh-frequency regions. Various portable communications equipments used in the military and an introduction to the laser and its uses in communications are included. Some of the applications presented are fairly new to the military community.

SYSTEMS

As discussed in chapter 1, the frequency range from elf to shf is from below 300 hertz up to 30 gigahertz. The first area we will cover is the lower frequency bands (medium frequency [mf] and below). You will then get a look at the microwave region and the high-frequency and ultrahigh-frequency range as it pertains to the naval tactical data system (NTDS).

MEDIUM FREQUENCY AND BELOW

Most of the receivers and transmitters that you will see used in the mf portions of the rf spectrum and below are very similar in design. In chapter 1 we discussed the operational uses of the equipment; now let's look at the equipment itself.

Equipment items covered in this and other chapters are meant to be merely representative of equipment that may be encountered in naval communications. No attempt will be made to include all of the possible equipment or equipment configurations.

Transmit Equipment

You should realize the transmitters used in bands of medium frequency and below are similar to those you studied in chapter 2. In other words, a transmitter used in one frequency range is basically the same as one used in another range. However, there are some differences. Two of the differences are component size and the use of a technique called DOUBLING UP.

The components used in bands of medium frequency and below are much larger physically than the ones previously discussed. This is because of the higher operating voltage and current levels required to produce the very high-powered rf outputs needed for the uses covered in chapter 1. A given resistor used in an hf application may be rated at 1/2 watt, whereas the same resistor used in a lower frequency application would probably be rated in tens or even hundreds of watts.

A block diagram of a doubled-up transmitter is shown in figure 5-1. Remember, bands of medium frequencies and below are used almost exclusively for broadcast and are on the air continuously. Doubling up increases reliability. As you can see, two transmitters are located in the same equipment cabinet. This allows you to quickly transfer circuits if one should fail. This dual installation also allows both amplifiers to be used together to double the output power. When you use this application, you sacrifice the doubling-up capability of only the power amplifier. All the other components are still available as backups. Let's go through figure 5-1 and describe the block functions.

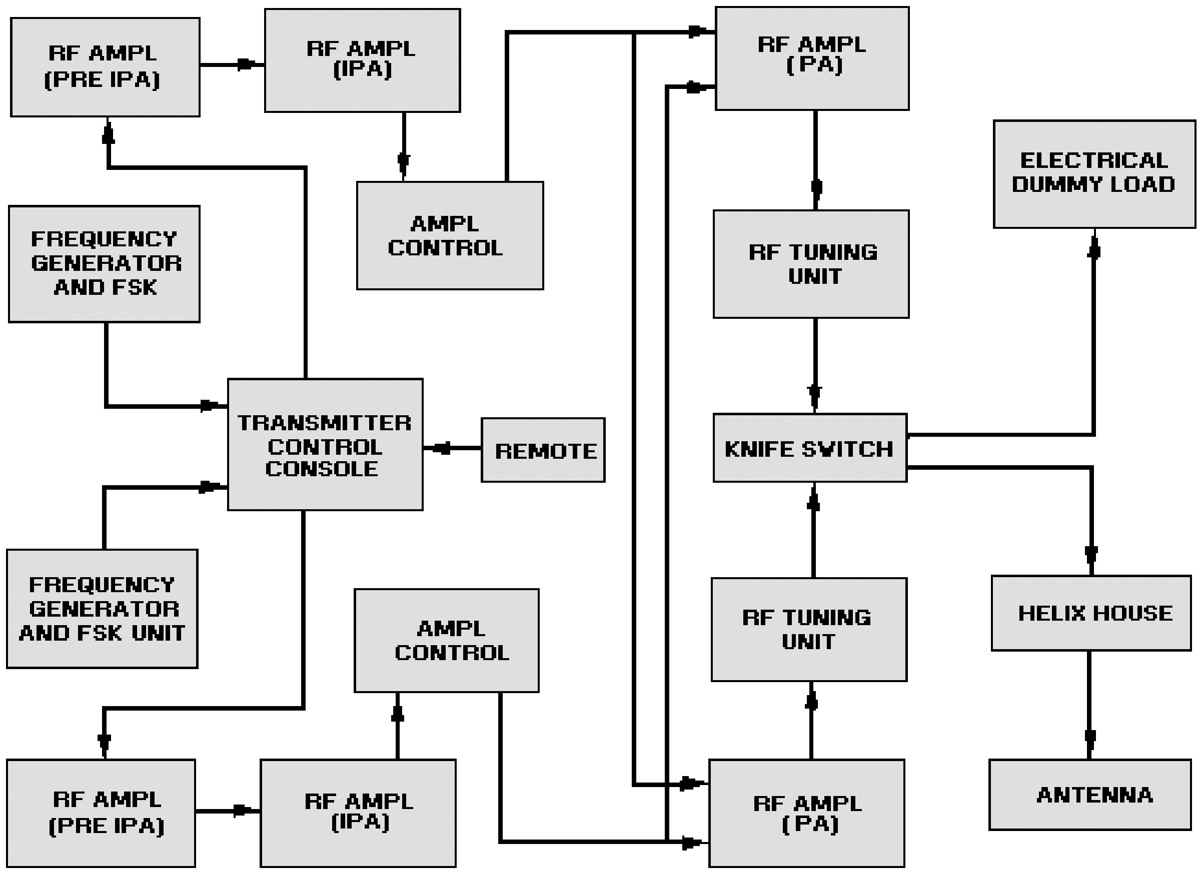


Figure 5-1.—Doubled-up transmitter block diagram.

The frequency generator part of the frequency generator and fsk block is an oscillator. It provides the carrier frequencies for the cw mode. The fsk part is a FREQUENCY SYNTHESIZER (a frequency source of high accuracy). It makes both the mark and space frequencies from a very stable clock oscillator. The keying pulses determine which fsk frequency the keyer chooses to transmit. This signal is then sent to the transmitter control console where it is distributed to the first rf amplifier. This amplifier is referred to as the preliminary intermediate-power amplifier (pre-ipa). The pre-ipa uses linear, untuned, push-pull, rf amplifiers to provide amplified rf to drive other rf amplifiers. The pre-ipa output goes to the intermediate power amplifier (ipa).

The ipa receives the pre-ipa output, amplifies the signal, and drives other selected power amplifiers. The ipa is a single-stage, untuned, linear, push-pull, rf circuit that uses water and forced-air cooled tubes.

Signals are then sent through the amplifier control, where they are used for signal monitoring purposes before being applied to the final rf amplifier (pa). The pa amplifies the signal to the final desired power level. The pa also contains variometers (variable inductors) for coupling. This coupled output is fed to the rf tuning unit.

The rf tuning unit consists of variable oil-filled capacitors and a fixed inductor for frequency tuning. The signal is then sent to a knife switch. This switch simply routes the signal to the DUMMY LOAD or the antenna by way of the HELIX HOUSE. (A dummy load is a nonradiating device the absorbs the rf and has the impedance characteristics of the antenna.) The dummy load is impedance matched to the pa. It allows testing of the pa without putting a signal on the air. When the equipment is in an operating mode, the dummy load is not used. The helix house is a small building physically separated from the transmitter location. It contains antenna loading, coupling, and tuning circuits. The main components consist of a HELIX (large coil) and variable inductors. The signal is fed from the helix directly to the antenna. Sometimes two antennas are used.

Antenna designs vary with the amount and type of land available, desired signal coverage, and bandwidth requirements. Figure 5-2 shows a simplified transmit antenna. The Navy uses TOP-HAT (flat-top) capacitive loading with one or more radiating elements. Typical top hat antennas consist of two or more lengths of wire parallel to each other and to the ground, each fed at or near its mid point. The lengths of wire are usually supported by vertical towers. These antennas may take many shapes. The matching network shown is in the helix house. Figure 5-3 shows the installation at the naval communications unit in Cutler, Maine. The Navy has several of these types of installations. They are used primarily for fleet broadcasts and have power outputs in the .25- to 2-megahertz range. You should notice the transmitter, the location of the helix houses, and the dual antennas. You should also notice the transmission line tunnel. It is underground and over a half-mile long. Figure 5-4, view (A) and view (B), shows another antenna configuration. This array of monopoles (quarter-wave, vertically polarized stubs) is referred to as a TRIATIC antenna. A triatic antenna is a special form of a rhombic-arranged monopole array. This type of array is designed to transmit from a particular location. Triatics are all basically the same but have some design differences at each site. The physical differences compensate for differences in terrain. Now that we have looked at the transmit side, let's look at the receive side.

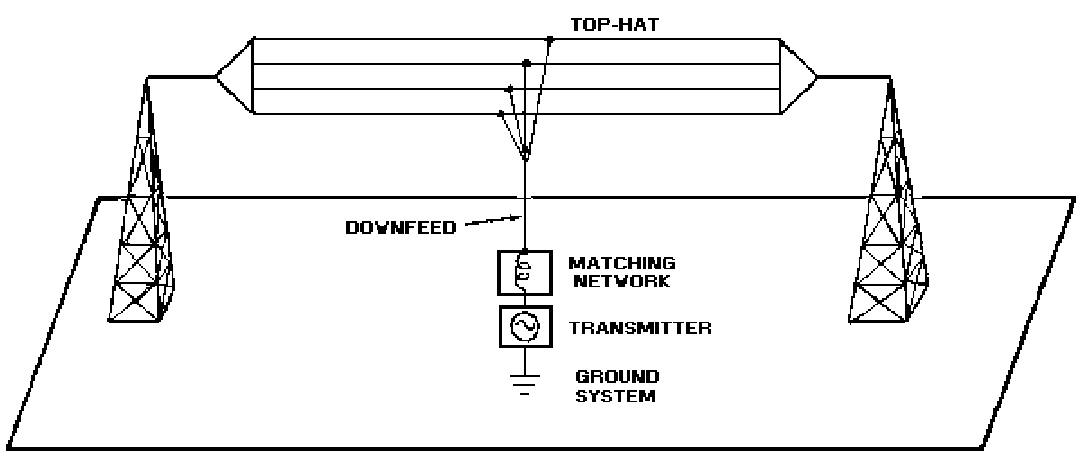


Figure 5-2.—Simplified vlf transmitting antenna.

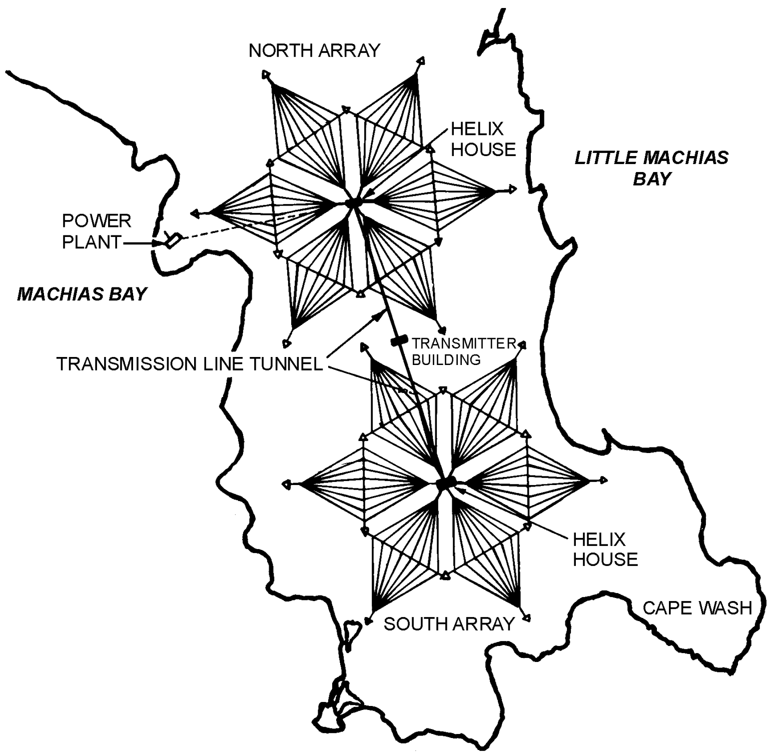


Figure 5-3.—Cutler, Maine antenna installation.

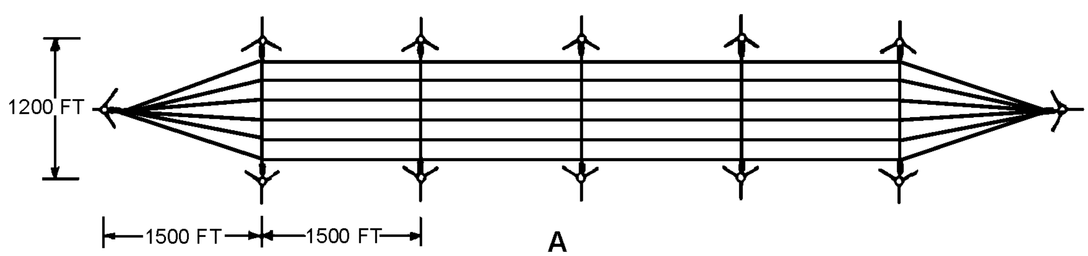


Figure 5-4A.—Triatic type antenna.

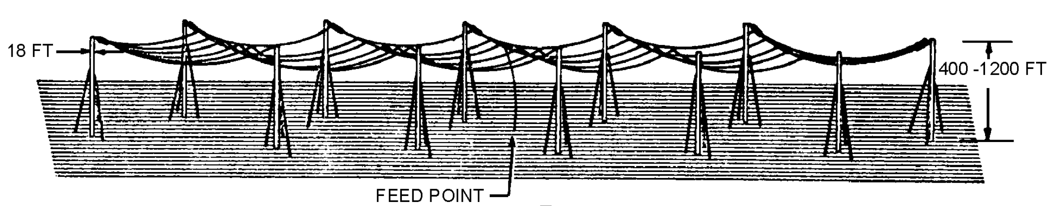


Figure 5-4B.—Triatic type antenna.

Receive Equipment

The receiver you will study here is fundamentally the same as those we covered in chapter 2. A receiver used in this frequency range is about the same electrically as one used in any other range. Figure 5-5 shows the receiver we will discuss. It is a highly sensitive, special purpose receiver because it is capable of splitting-out multiplex signals for detection and reproduction. This receiver covers the frequency range of 3 kilohertz to 810 kilohertz in five bands. It will receive most types of signals, including AM, cw, ssb, fm, and fsk. All operator controls are on the front panel, and a speaker and headset jack permit monitoring.

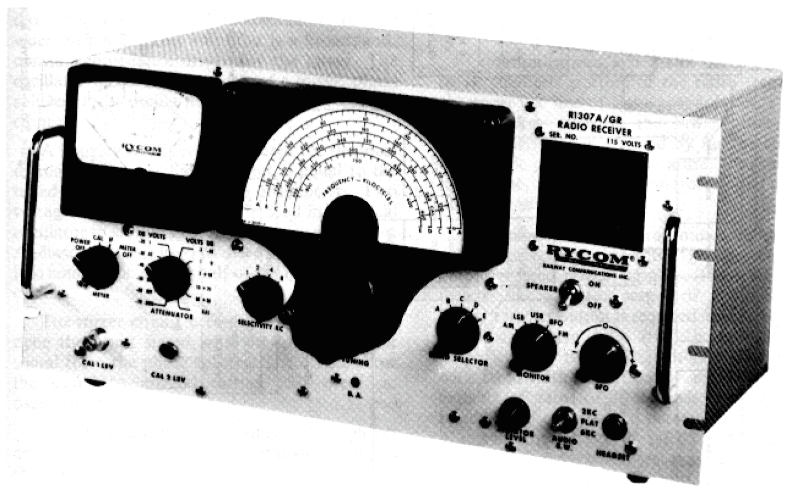


Figure 5-5.—Typical vlf to mf receiver.

Our receiver has five basic stages excluding the power supply. With the exception of a video amplifier in place of an rf amplifier, the circuits perform the functions normally associated with a typical receiver. Figure 5-6 is a block diagram showing the signal paths of the receiver. The input stage consists of a low-pass filter, an attenuator, a calibration oscillator, and a video amplifier. The low-pass filter passes input frequencies below 900 kilohertz. These frequencies are passed to the attenuator, which sets the signal to the proper level to drive the mixer. This minimizes noise and distortion. The calibration oscillator produces a 250-kilohertz output. It is used to calibrate the receiver level and to check for tuning dial accuracy. The input signal is direct-coupled from the attenuator to the video amplifier. This amplifier is a broadband, constant-impedance driver for the mixer. The oscillator-mixer stage consists of a mixer, phase splitter, local oscillator, and frequency control circuits.

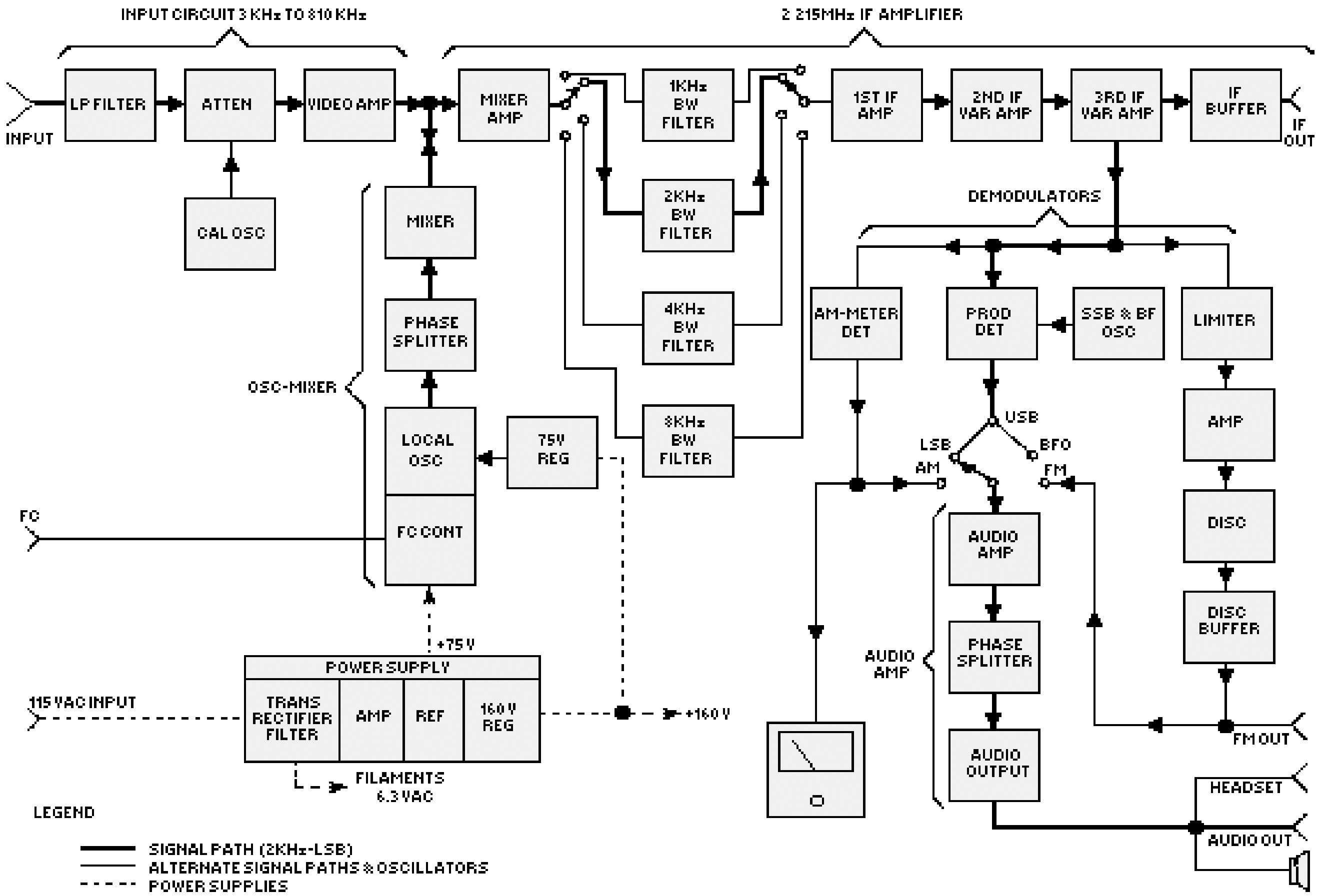


Figure 5-6.—Receiver block diagram.

A Hartley configuration is used for the local oscillator. The oscillator output is equal to the tuned frequency plus 2.215 megahertz. Two voltage-variable capacitors are used in the local oscillator to stabilize small frequency variations. A phase splitter is used to drive the mixer diodes into conduction during half of the local oscillator cycle.

The mixer circuit uses the diodes to heterodyne the input signal with the local oscillator signal from the phase splitter. The diodes short the signal to ground during half the local oscillator cycle.

The IF amplifier stages consist of the mixer amplifier, four selectable bandwidth filters, three IF amplifiers, and an IF buffer amplifier.

The output of the mixer is directly coupled to the mixer amplifier. The IF signal is then directed through one of four bandwidth filters to the first IF amplifier. The signal proceeds to the second and third IF amplifiers for amplification before demodulation. An IF buffer amplifier is used to pass the IF to the IF OUT jack and to isolate this jack from the rest of the circuitry.

Three demodulators are used in this receiver. They are the AM detector, product detector, and fm detector. The AM detector is used to demodulate AM signals. The product detector demodulates ssb, cw, and fsk signals, and the fm detector demodulates fm signals only. An output from the fm detector is provided to the FM OUT jack. This fm output may be used for recording or detailed analysis.

The output from the selected demodulator is amplified by the audio amplifier and presented simultaneously to the HEADSET jack, AUDIO OUT terminals, and the speaker.

You should note that this receiver, as with most others, requires no other special equipment. It uses a standard df loop or a whip antenna. If it is installed in a submarine, a trailed, (towed) long-wire antenna may be used.

MICROWAVE

Communications systems in the 1 gigahertz to 10 gigahertz portion of the radio frequency spectrum use line-of-sight propagation. Propagation takes place in the lower atmosphere (troposphere). It is affected by factors such as barometric pressure, temperature, water vapor, turbulence, and stratification (forming of atmospheric layers).

A typical microwave transmitter includes an exciter group, a modulator group, a power amplifier, and power supplies. The transmitter usually has a power output of about 1 watt. When a higher output is required (about 5 watts), a traveling-wave tube (twt) is used as the amplifier. (A twt is a high-gain, low-noise, wide-bandwidth microwave amplifier. It is capable of gains of 40 decibels or more, with bandwidths of over an octave. The twt was discussed in chapter 2 of NEETS, Module 11, *Microwave Principles*.) A typical microwave receiver contains an rf-IF group, local oscillator, demodulator, and amplifier. Both transmitters and receivers contain special circuits because of the high operating frequencies and critical frequency stability requirements.

Line-of-Sight System

A line-of-sight (los) microwave system consists of one or more point-to-point hops as shown in figure 5-7. Each hop is designed so that it can be integrated into a worldwide communications network. Los systems have many characteristics. In these systems, propagation is only affected by changes in the troposphere. The distance between microwave system hop points ranges from 50 to 150 kilometers (31 to 95 statute miles). These systems are capable of handling up to 600 4-kilohertz voice channels and can also transmit television. These signals can usually be transmitted with less than 10 watts of power. Both the transmit and receive antennas are horn-driven paraboloids that provide high gain and narrow beam widths. In some applications, as shown in figure 5-8, plane reflectors are used with the paraboloids. These systems are very reliable. They are designed to operate over 99 percent of the time. These systems are well adapted to multichannel communications and closed circuit television.

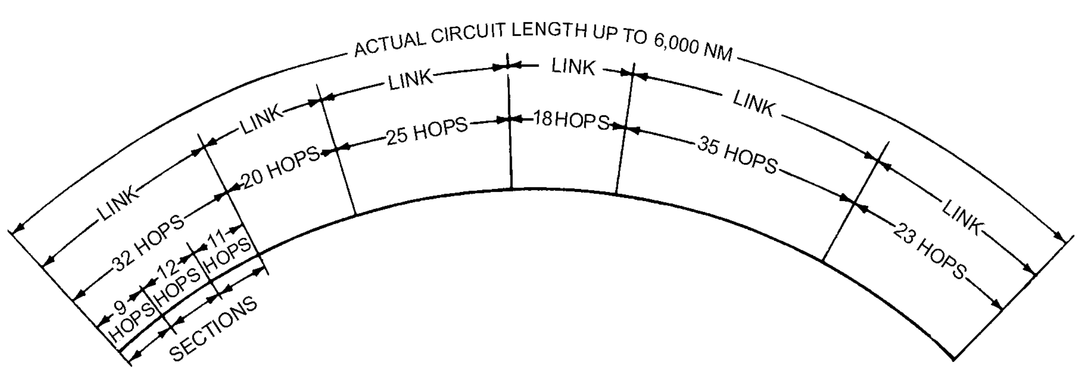


Figure 5-7.—Typical hop-link and section allocation.

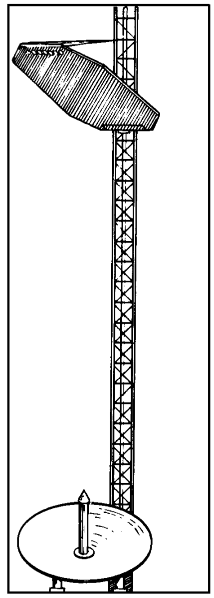


Figure 5-8.—Parabolic antenna and passive reflector combination.

Now let us take a look at another system. It is called the tropospheric-scatter microwave system. But first, you may want to review tropospheric propagation in NEETS, Module 10, *Introduction to Wave Propagation, Transmission Lines, and Antennas.*

Tropospheric Scatter System

A tropospheric-scatter (tropo-scatter) microwave system gets results similar to those of the line-of-sight system. It does it in a different way. The los system uses towers to relay information.

The tropo system uses the turbulence in the layer between the troposphere and the stratosphere to bounce signals back to earth. This method provides several hops and communications beyond los. The propagation reliability and communications capability is the same. The transmission range is up to 800 kilometers (500 statute miles). Transmitter output power may be up to 75 kilowatts depending on the operational requirements. The antennas are horn-driven paraboloids and may be as large as 50 to 60 feet in diameter. Figure 5-9 shows a typical tropospheric-scanner antenna. Remember that hf has a hop distance (skywave) of about 1,400 miles; the distance of one hop for a line-of-sight system is between 31 and 95 miles. The tropospheric-scatter system conveniently fills the gap between these distances.

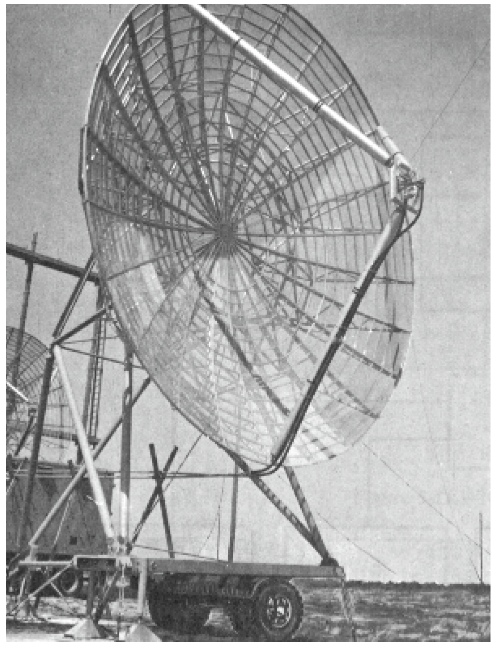


Figure 5-9.—Mobile 30-foot tropospheric-scanner antenna.

Both of these systems are used ashore. You're now going to get a look at a shipboard data information exchange system.

Q1. What is a dummy load?

Q2. What is the function of a product detector?

Q3. What is the frequency range of the mf band?

Q4. Microwave systems use what portion of the atmosphere?

Q5. What is the voice channel capacity of an los communications system?

Q6. What is the one-hop transmission range of a tropospheric-scatter system?

NAVAL TACTICAL DATA SYSTEM

In recent years, the Navy has introduced several new highly technical and effective combat weapons systems. However, these weapons systems did not solve the basic combat command problems that confront our Navy. In combat, a fleet continues to be involved in close-range offense and defense. During close-range combat, the shipboard combat information center (CIC) is involved in complex tactical situations. These situations require intelligent and highly important decisions. Each decision has to be made in a short period of time. You will find the speed at which these combat situations must be solved is inconceivable to someone thinking in terms of typical CIC operations of the recent past. Therefore, the NTDS was developed by the U.S. Navy as a command tool for commanders in tactical combat situations.

Objectives

The naval tactical data system (NTDS) is based on the interaction of humans and machines. The NTDS helps coordinate fleet air defense, antisubmarine warfare, and surface defense operations. Through automation, the NTDS provides commanders with a broad picture of the current tactical situation. It also assists them in directing their operations in time to intercept and destroy all potential enemy threats. The use of digital computers and digital data processing techniques reduces reaction time and increases force effectiveness.

NTDS uses a variety of equipment. This equipment includes transmitters, receivers, cryptographic equipment, high-speed digital computers, magnetic tapes, disks, and a variety of displays. Figure 5-10 shows the NTDS equipment grouping and how it interfaces with the weapons and sensor systems of a ship. Figure 5-11 shows the NTDS system inputs and outputs. As you can see, large amounts and various types of information are provided to or taken from the NTDS. Now that you have seen the types of information associated with the NTDS, let's look at how this information is transmitted and used.

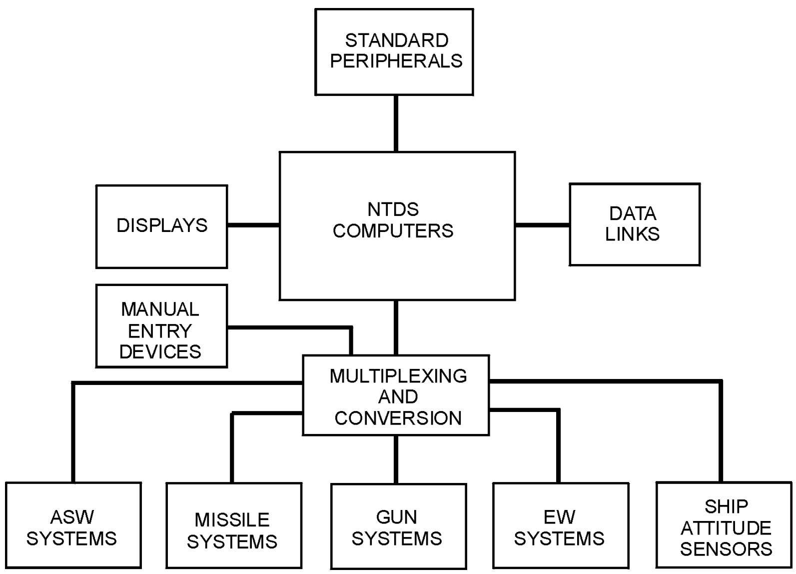


Figure 5-10.—NTDS equipment grouping.

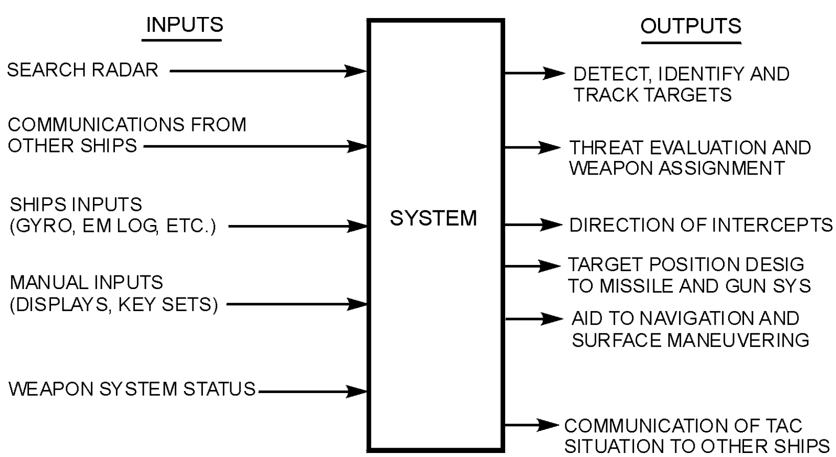


Figure 5-11.—NTDS system inputs/outputs.

NTDS Data Transmission Subsystems

NTDS uses three separate data transmission links to maintain tactical data communications between tactical units. Figure 5-12 illustrates these links. Each link is able to transfer data rapidly to other ships, aircraft, and shore facilities without the delay of human interface (link 14 receive is an exception to this). The data processing subsystem formats the messages for each of the data links. These messages are based on shipboard inputs (from displays, sensors, and other data links).

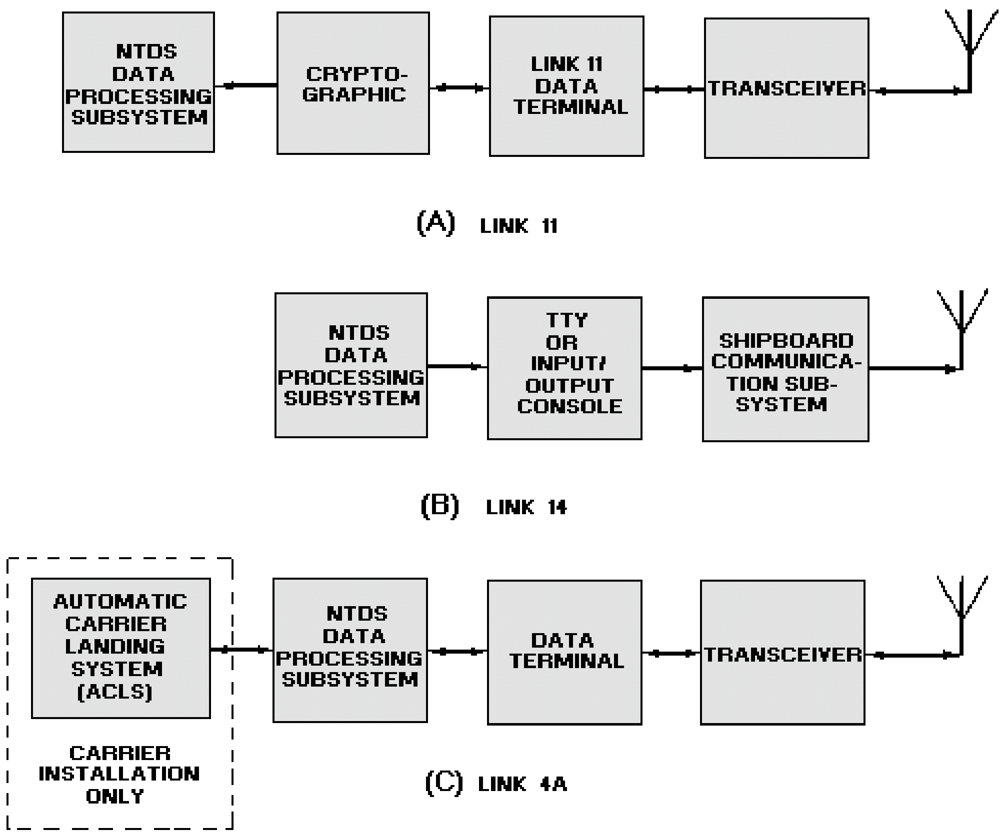


Figure 5-12.—NTDS communications links.

The automatic data communications links provide the operational commander with a high-speed, accurate mode of tactical communications. Link 11 provides high-speed, computer-to-computer transfer of tactical information, command orders, and unit status to all tactical data systems. View A shows you this configuration. The type of tactical information currently transferred is surface, subsurface, air, and EW track information. Data is provided on friendly, hostile, and unknown identity tracks. This broadcast originates through console button actions by the console operators.

Link 14 provides a means of transmitting track information to those units not capable of participating in the link 11 network. View B shows this network. This is a one-way broadcast of information.

Link 4A permits the computer to take control of the autopilot in an equipped aircraft. Also this link can control a plane under other situations. It may control a flight out to a strike area and return it to base without the need for pilot action. The pilot also has the option of overriding the link. The pilot may use the visual display to aid in understanding the intercept controller, or to totally ignore the link 4A transmission. View C shows this link used in conjunction with the automatic carrier landing system (ACLS).

Figure 5-13 is a drawing of an intersystem communications employment diagram. It shows the overall possibilities and flexibility of the NTDS. The new terms shown are defined below:

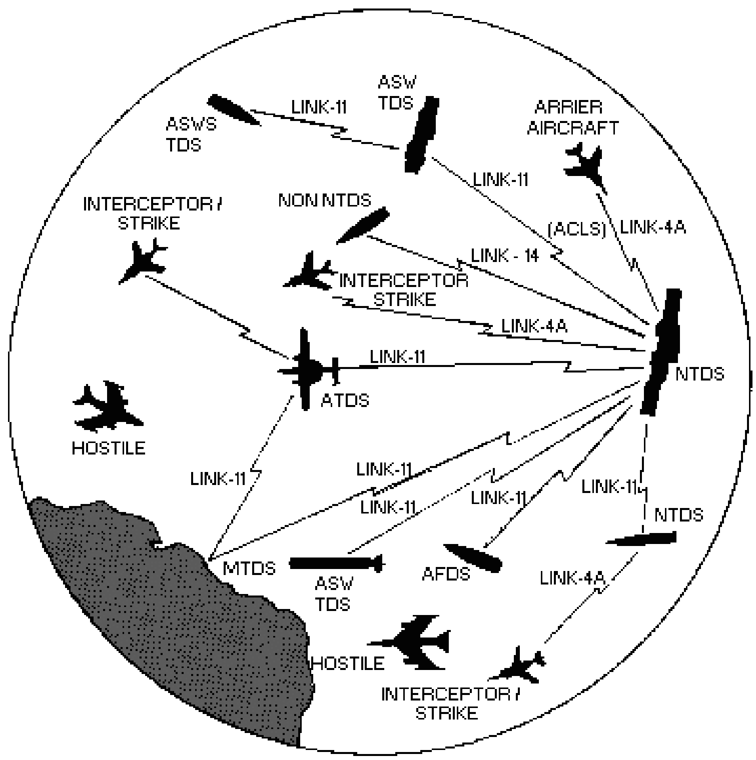


Figure 5-13.—Intersystem communications employment.

- MTDS-Marine tactical data system
- AFDS-Amphibious flagship data system
- ATDS-Airborne tactical data system
- ASWTDS-Antisubmarine warfare tactical data system

Now that we've looked at a complex and stationary system, let's study some fundamental portable equipment.

Q7. What is the primary advantage of NTDS over conventional systems?

Q8. What are the three NTDS data transmission subsystems?

PORTABLE EQUIPMENT

Portable and pack radio sets must be lightweight, compact, and self-contained. Usually, these sets are powered by a battery or a hand generator, have low output power, and are either transceivers or transmitter-receivers. A transceiver consists of a transmitter and a receiver that share common circuits and are housed in the same case or cabinet. A transmitter-receiver is the combination of two separate pieces of equipment that are used together. Navy ships carry a variety of these radio sets for emergency and amphibious communications. The numbers and types of equipment vary according to the individual ship.

EMERGENCY EQUIPMENT

One piece of emergency equipment is shown in figure 5-14. It is a rugged emergency transmitter carried aboard ships and aircraft for use in lifeboats and life rafts. The transmitter operates on the international distress frequency (500 kilohertz) and the survival craft communications frequency (8,364 kilohertz).

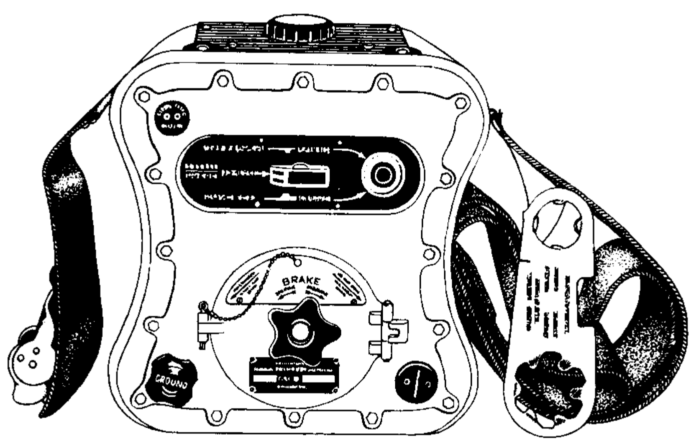


Figure 5-14.—Typical emergency lifeboat transmitter.

The complete radio transmitter, including the power supply, is contained in an aluminum cabinet that is airtight and waterproof. The cabinet is shaped to fit between the legs of the operator and has a strap for securing it in the operating position.

The only operating controls are a three-position selector switch and a push-button telegraph key. A hand crank screws into a socket in the top of the cabinet. The generator, automatic keying, and automatic frequency changing are all operated by turning the hand crank. While the hand crank is being turned, the set automatically transmits the distress signal SOS in Morse code. The code consists of six groups of SOS followed by a 20-second dash. It is transmitted alternately on 500 kilohertz and 8,364 kilohertz. The frequency automatically changes every 50 seconds. These signals are intended for reception by two groups of stations, each having distinct rescue functions. Direction-finding stations cooperating in long-range rescue operations normally use 8,364 kilohertz, whereas aircraft or ships locally engaged in search and rescue missions use 500 kilohertz.

Besides the automatic feature, you can key the transmitter manually on 500 kilohertz only. This is done by means of a push-button telegraph key.

Additional items (not shown) packaged with the transmitter include the antenna, a box kite, and balloons for supporting the antenna. Hydrogen-generating chemicals for inflating the balloon and a signal lamp that can be powered by the hand-crank generator are also included.

The equipment floats and is painted brilliant orange-yellow to provide good visibility against dark backgrounds.

A transceiver is shown in figure 5-15. It is portable, battery powered, and has two channels. It provides homing information and two-way voice communications between life rafts and searching ships and aircraft. This transceiver is a microminiature, solid-state, hand-held radio that operates on the 121.5-megahertz and the 243-megahertz guard channels. The transceiver has four operating controls. These are the volume (VOL) control, the two-position FREQUENCY SELECTOR, the PUSH-TO-TALK/ CODE button, and the three-position MODE switch.

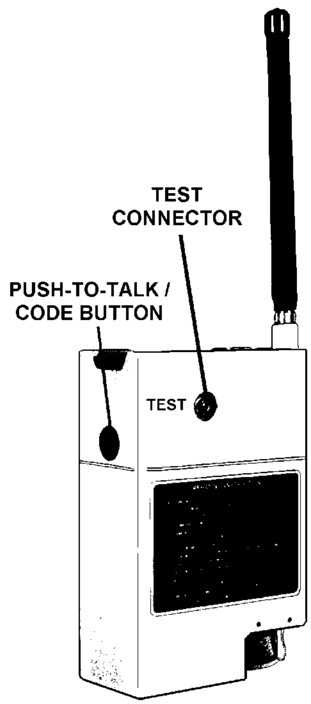


Figure 5-15.—Emergency portable transceiver.

The antenna is a rubber covered, omnidirectional, flexible whip antenna that is 7.74 inches long. The batteries supplied with the radio set are lithium D cells. Each cell is fused to protect against damage from external short circuits. Two cells are installed in the transceiver and four are packaged as spares.

OPERATIONAL EQUIPMENT

An operational transceiver is shown in figure 5-16. It is watertight, lightweight, portable, and operates in the vhf and uhf range. You can use any of 1,750 channels, spaced 200 kilohertz apart, in the 225-400 megahertz range. Its mode of operation is AM voice and it supplies an average output power of 3 watts. It was designed mainly for manpack (backpack) use, but it may also be used at a fixed station or in vehicles when certain accessories are added. When not in use, the equipment is disassembled and stowed in a special aluminum case similar to an ordinary suitcase.

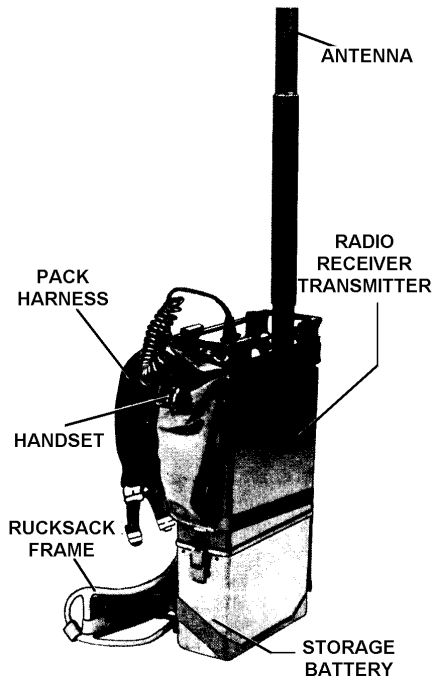
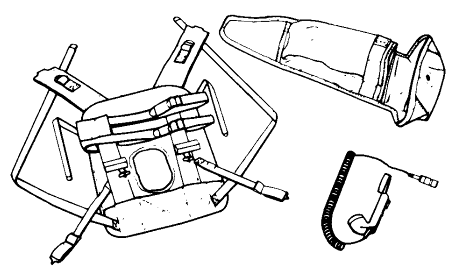


Figure 5-16.—Typical vhf/uhf backpack transceiver.

Figure 5-17 shows a typical vhf miniaturized manpack radio set. View A shows the pack frame, the handset, and the canvas accessory pouch. The pouch contains two antennas (one flexible steel band-type whip and one collapsible rigid whip). The handset fits in the pouch when not in use. View B shows the transmitter-receiver.



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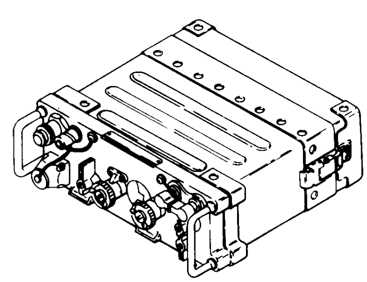

B

Figure 5-17.—Vhf receiver-transmitter.

Now that you have learned about portable equipment, let's look at one of the newest areas of communications. You are going to learn the fundamentals of how a laser works and how it may be used in the field of communications.

Q9. What are the three main design considerations of portable equipment?

LASERS

The word LASER is an acronym for light amplification by stimulated emission of radiation. The laser is widely used in industry, and experimental work is being done with it in communications. You will find a laser is similar to uhf and microwave power sources and could replace either of them in point-to-point communications.

THEORY OF OPERATION

Lasers take energy at (or near) the visible light spectrum and convert it to a very narrow and intense beam in the same region. A close relative of the laser is the light emitting diode (LED). The LED takes dc or low frequency ac power and converts the energy into visible light.

The principle of the laser is somewhat similar to that of a very high-Q cavity resonator. Chapter 1 of NEETS, Module 11, *Microwave Principles*, explains cavity resonators. The laser is shock-excited by a spark transmitter. This transmitter is called a spark transmitter because it uses the discharge of a capacitor through an inductor and a spark gap as a source of rf. While the input energy of the laser covers a wide band of frequencies, the output is on one frequency. Energy outputs of the laser are either INCOHERENT or COHERENT. For example, if you turn on a transmitter with no modulation, you will get coherent radiation. When you connect a noise source to an antenna, the result is incoherent radiation.

Lasers can be either cw or pulsed. Actually, lasers are little different from conventional oscillators. However, the way lasers convert energy from one form to another is quite different. In conventional oscillators, dc power from the collector is converted to rf energy. The frequency is for the most part independent of the molecular or atomic structure of the generator. This is not true for the laser. Laser conversion takes place directly within the molecular structure of a crystal or gas. The external circuits have little effect on actual output frequency. The fact that the light from an LED is always the same color results from similar conditions. In a laser, incoherent light excites the electrons in the atoms to higher energy levels than they normally would have. The new energy states are unstable and the electrons drop down to lower energy levels. Energy is then released in the form of light.

Figure 5-18 shows the ends of the crystal or glass tube laser with light waves reflecting back and forth between two mirrored surfaces. One mirror is only partially reflective, and light energy is transmitted through it to form the light beam. You will find that power sources for lasers include flash tubes or, in the case of diode-type lasers, dc power supplies.

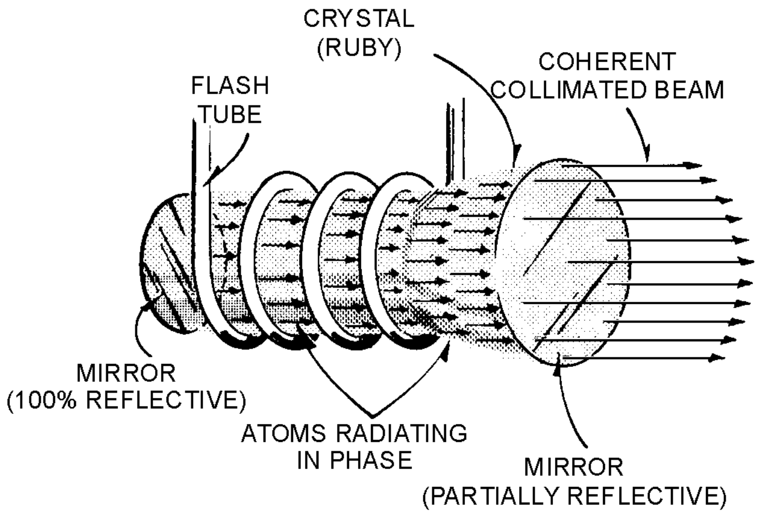

Figure 5-18.—Simple laser.

COMMUNICATIONS APPLICATIONS

High-energy lasers have very small power losses. As a result, a laser with a 2- or 3-inch initial beam can be used to communicate directly with a distant planet. However, from a communications standpoint, they do have some drawbacks. While laser energy is capable of being formed into a very narrow beam, it is still subject to the same difficulties as any other form of light transmission. Fog and other adverse weather conditions can absorb the light. Small atmospheric temperature variations can cause deflection and scattering. An optical waveguide was designed to help overcome this problem. It consists of a thin dielectric fiber clothed by another dielectric coating several wavelengths thick. It has been successfully used to move the beam over considerable distances and around bends. The use of optical waveguides is known as FIBER OPTICS. A number of fibers can be paralleled to reduce the attenuation through the waveguide. This technique has resulted in an inexpensive telephone system with a bandwidth greater than that of previous methods. Researchers are attempting to develop a laser that will operate in the blue-green portion of the visible spectrum. Water offers little attenuation to the blue-green band of frequencies. Because of this, blue-green communications lasers could possibly penetrate the ocean to great depths.

This could give us a very secure undersea communications link.

Q10. Lasers operate in what portion of the frequency spectrum?

Q11. What are the two types of lasers?

Q12. What are the effects of adverse weather on the laser beam?

SUMMARY

Now that you have completed this chapter, a review of what you have learned is in order. The following summary will refresh your memory of new terms.

DOUBLING UP is a type of two-equipment installation where one unit can be substituted for another in the event of failure.

FREQUENCY SYNTHESIZER is a frequency source of high accuracy.

DUMMY LOAD is a nonradiating device that absorbs the rf and has the impedance characteristics of the antenna.

HELIX HOUSE is a building at a transmitter site that contains antenna loading, coupling, and tuning circuits.

A **HELIX** is a large coil of wire. It acts as a coil and is used with variable inductors for impedance matching of high-power transmitters.

TOP-HAT antennas are center-fed and capacitively loaded.

TRIATIC is a special type of monopole antenna array.

LASER is an acronym for light amplification by stimulated emission of radiation.

COHERENT refers to radiation on one frequency or nearly so.

INCOHERENT refers to radiation on a broad band of frequencies.

FIBER OPTICS are conductors or optical waveguides that readily pass light.

MTDS is an abbreviation for the marine tactical data system.

AFDS is an abbreviation for the amphibious flagship data system.

ATDS is an abbreviation for the airborne tactical data system.

ASWTDS is an abbreviation for the antisubmarine warfare tactical data system.

ANSWERS TO QUESTIONS Q1. THROUGH Q12.

A1. An impedance-matched device capable of absorbing all of a transmitters power.

A2. It demodulates ssb, cw, and fsk signals.

A3. 300 kilohertz to 3 megahertz.

A4. Troposphere.

A5. Up to 600 4-kilohertz channels.

A6. Up to 800 kilometers (500 statute miles).

A7. Speed.

A8. Links 4A, 11, and 14.

A9. They must be lightweight, compact, and self-contained.

A10. At or near visible light.

A11. Cw or pulsed.

A12. It absorbs it.